# POTENTIAL SYNERGIES OF MULTIPURPOSE RUN-OF-RIVER HYDROELECTRIC POWERPLANTS

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In countries where hydropower potential is mostly exploited yet, new hydroelectric powerplants can find general approval only as multipurpose projects. In addition to technical purposes (energy production, flood control or irrigation), run-of-river projects should also satisfy environmental, landscape and social constraints. Integration of different purposes increases the degree of project complexity. A new methodology to deal with this complexity is thus necessary to develop synergies between the purposes. The here proposed method combines a qualitative analysis with a semi-quantitative one.

Developed by two socio-economists, this qualitative network thinking approach consists of five steps. The problem identification allows understanding the relations between the variables. This assessment forms the basis for development and analysis of potential solutions. The best solution may generate a new situation and thus probably new problems to solve. Influences between variables are modeled referring to three aspects: direction, intensity and temporal shift. Diagram interpretations are summarized into a graph.

The graph results identify three kinds of variables, namely the ones influencing the size, the management and the objectives of the project. According to the configuration variables, implicitly contained in the graph, such a multipurpose project can be represented as in Fig. 1.

Weir height, reservoir surface, by-pass river and ecomorphologic adaptations are the four major size variables. The reservoir management is highlighted through the peak hydropower mitigation and the minimum discharge increase.

In order to bring an appropriate answer to reservoir management aspects, a quantitative analysis is performed. The reservoir operations are defined with three different heuristics and with three non-linear objective functions. This model is applied on the upper Swiss Rhone River to a reservoir of 1 km$^2$ created by a dam of 8.6 m height. Two typical Rhone River weeks are simulated. The first one represents a winter situation with strong inflow variations due to peak hydropower. The second one represents a summer situation with lower variations but with a higher average flow. Hourly flows and rating level curve are measured at the Branson gauging station (Switzerland).

The first heuristics produce a constant outflow. The reservoir completely absorbs the flow variations. The downstream river suffers from an artificial constant flow and the required reservoir volume is non-optimized. The second heuristics generate a constant reservoir water level. The downstream river preserves its hydropeaking. Energy production is maximized but the reservoir main's purpose isn't respected. This case represents the energy production reference (100% of energy production). The third heuristics produce a management between those two extremes. Around the inflow value, it produces an outflow strictly limited by tailwater discharge amplitude and gradient. Energy production remains at about 65 % of the maximum for a winter week (Fig. 2a), and at 87 % for a summer week.

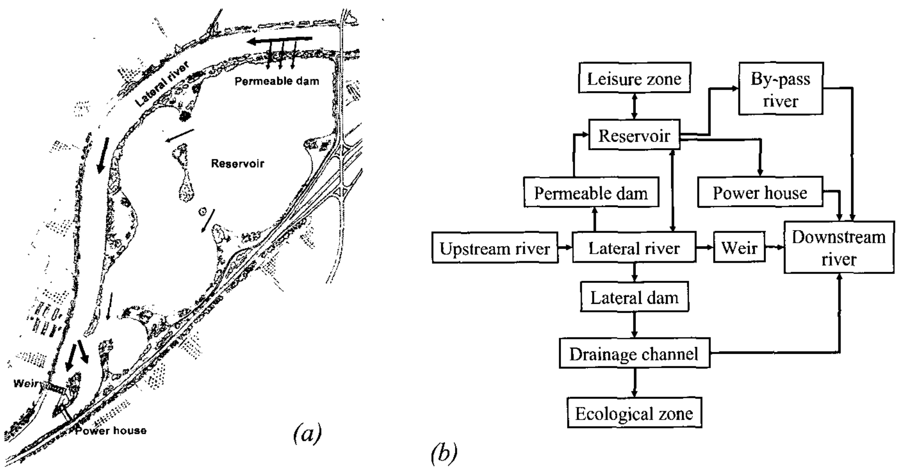


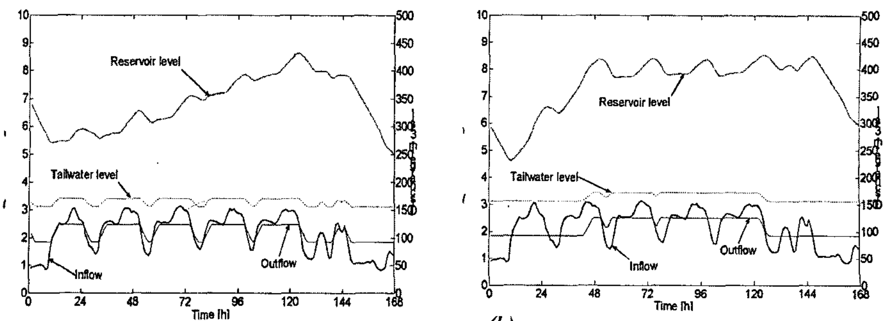

Fig. 1 Configuration of a multipurpose project; (a) *in situ* integrated; (b) conceptually represented.

Three different objective functions are defined in order to 1) minimize the required reservoir volume, 2) minimize the reservoir variation around initial level and 3) maximize the reservoir water level.

Winter regulation with the first function shows a weekly variation. To keep an acceptable minimum flow during the weekend, the reservoir accumulates water during working days. The second function presents the same trend but the reservoir remains as long as possible at its initial level. The last function keeps the reservoir level at its maximum during working days and empties it during the weekend. The next working day is then needed to fill up the reservoir again. Maximizing the level implicitly maximizes energy production. This production remains, with the third function, at about 80 % of the maximum for a winter week (Fig. 2b) and at 95 % for a summer week.

With the reduction of the reservoir fluctuation, the non-linear technique enhances both the downstream river ecological state and the reservoir possible uses (creation of biotopes, leisure activities and energy production).

*Keywords*: Multipurpose run-of-river powerplant; Complex system analysis; Peak hydropower mitigation; Energy production; Ecological integration




*(a)* *(b)*

Fig. 2 Winter week reservoir and flow regulations with downstream river amplitude of 30 cm and gradient of 8 cm/h; (a) third heuristics regulation; (b) non-linear programming regulation.